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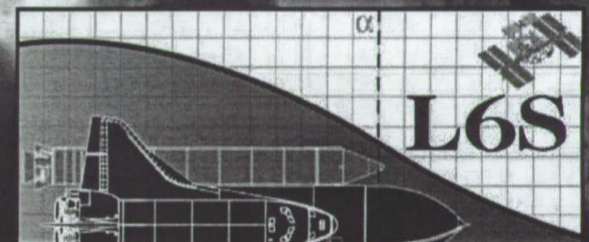


Simulation Modeling for Space Exploration

United Space Alliance, LLC (USA)



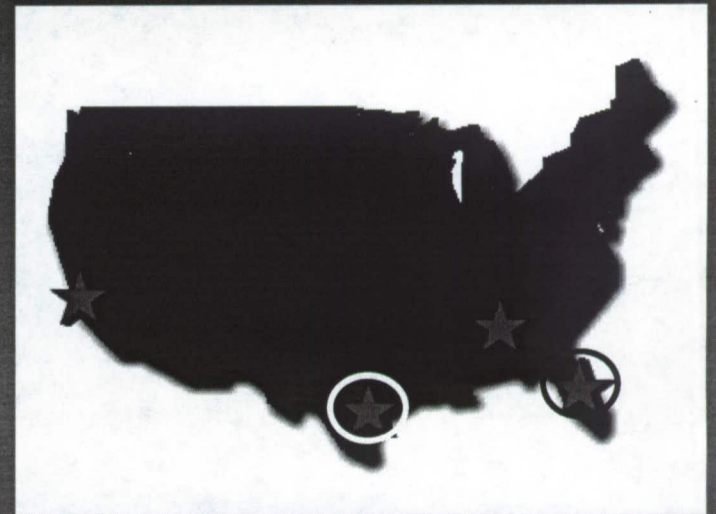
Dave Tucker
May 2006



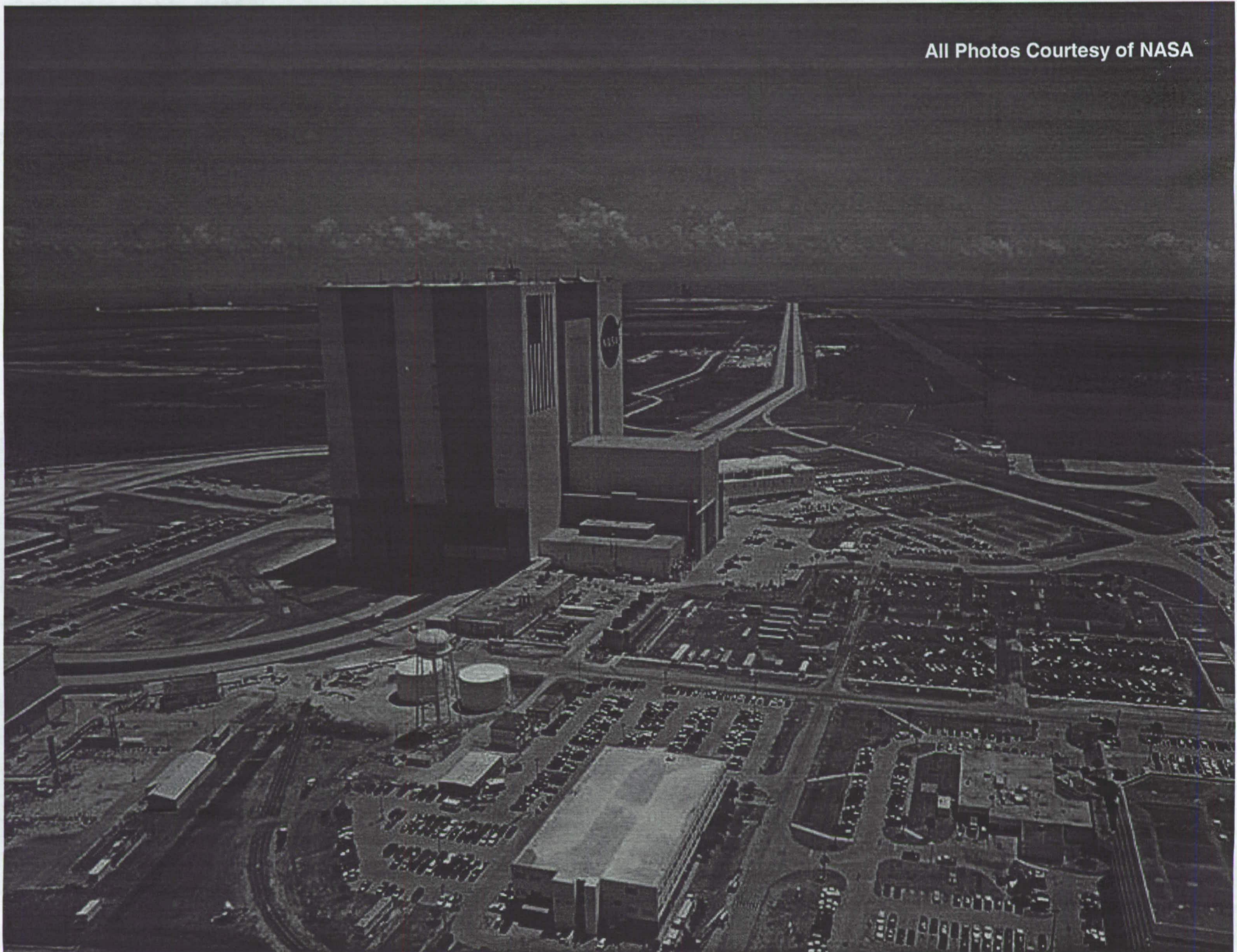
United Space Alliance (USA)

Who are we?

- Prime Contractor to NASA for Space Flight Operations Contract
- Responsible for all Space Shuttle Fleet & International Space Station processing operations
- Two primary locations:
 - Johnson Space Center, TX
 - Kennedy Space Center, FL
- About 10,000 employees



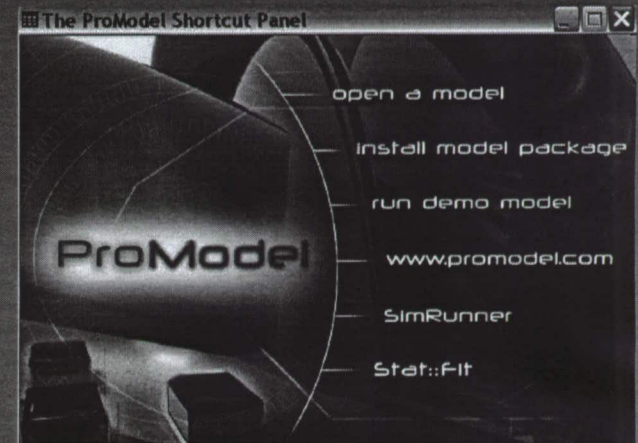
All Photos Courtesy of NASA



United Space Alliance (USA)

Simulation Experience:

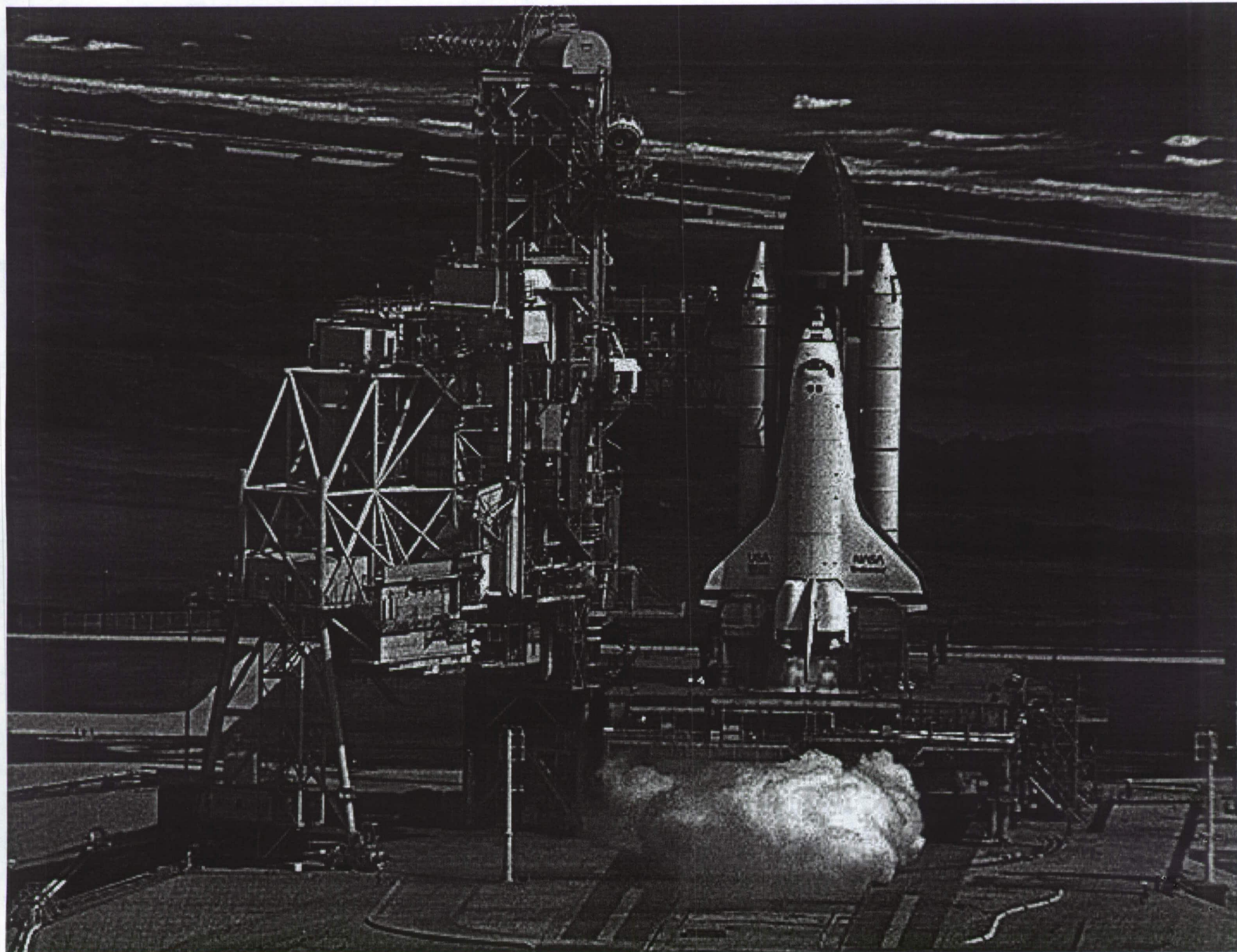
- Six years using ProModel
- Also use PM Process Simulator with Visio
- About three dozen USA employees trained in PM
- Primary ProModel users: IE's, P&M, & other staff
- Completed over two dozen simulation projects
 - Shop Layouts
 - Paper Processes
 - Flight Hardware Processing
 - Manufacturing Operations

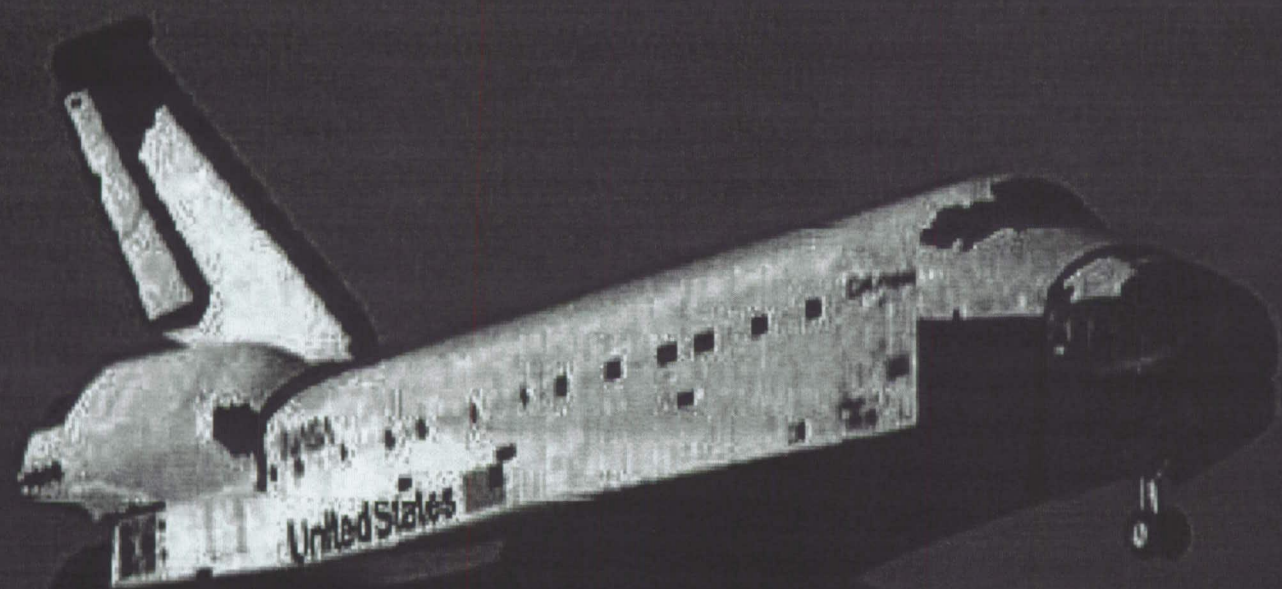


Today's Shuttle Program

Space Transportation System:

- Fleet of three Space Shuttle Orbiters**
- Solid Rocket Boosters (SRBs) & External Tank (ET)**
- Transport crews & cargo to low earth orbit & International Space Station (ISS)**
- Orbiters land at Kennedy Space Center in FL or Edwards Air Force Base in CA**
- Orbiters & SRBs are refurbished; ET is not**
- Flown over 100 Shuttle Missions since 1981**

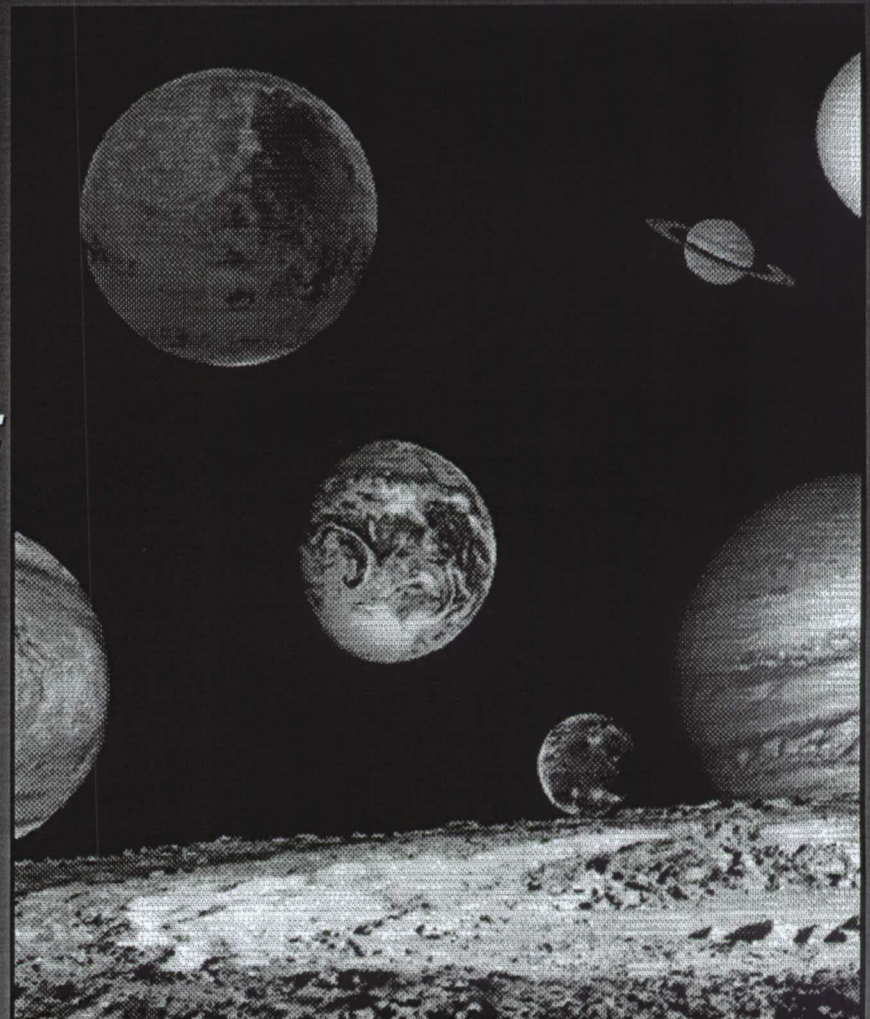




Tomorrow's Space Program

Vision for Space Exploration:

On January 14, 2004, President Bush put NASA on a new course into the cosmos. The Vision for Space Exploration focused the agency on a bold new mission: landing humans on the moon before the end of the next decade, paving the way for eventual journeys to Mars and beyond.

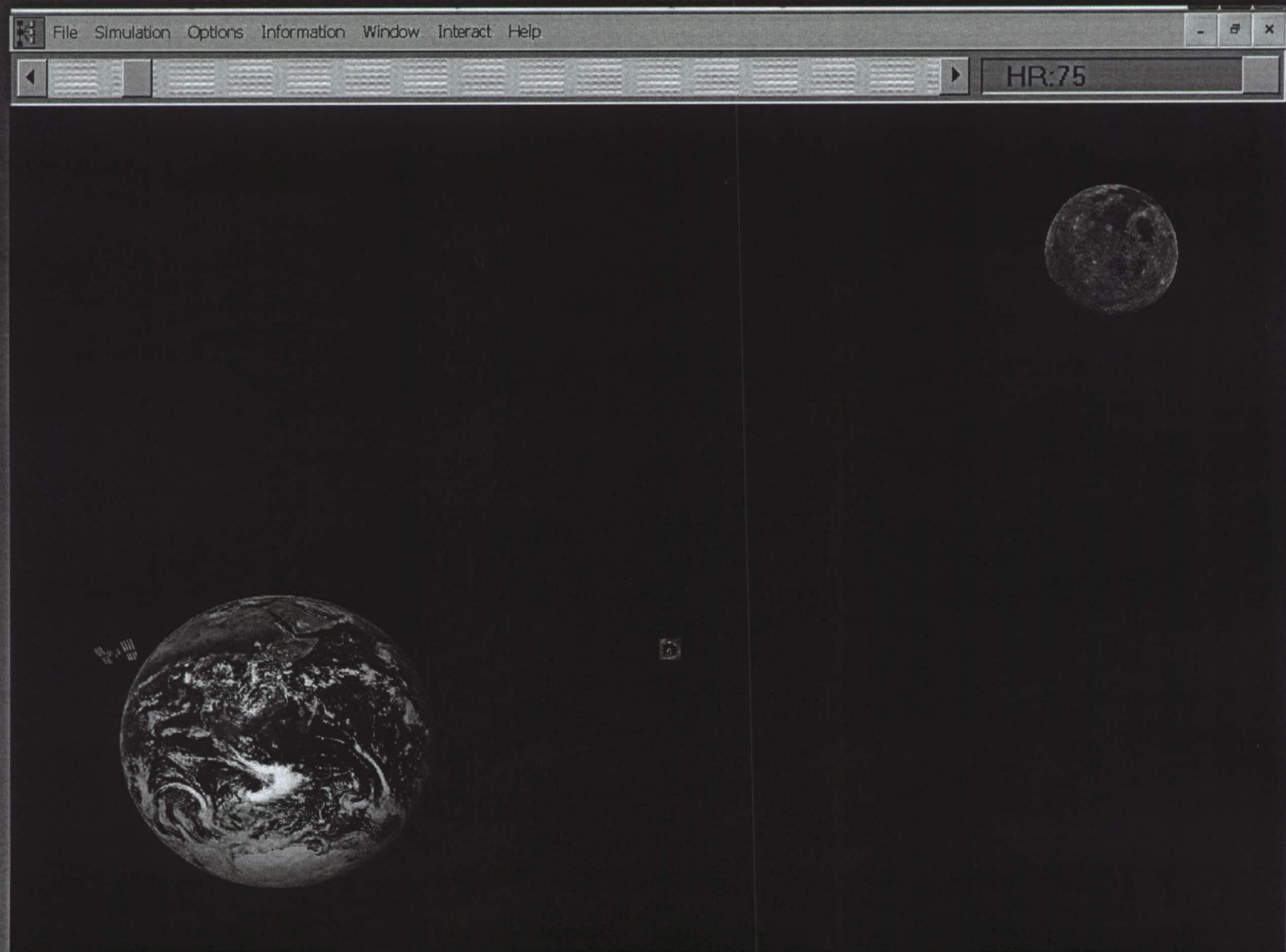


Vision for Space Exploration

United Space Alliance:

- Partnered with several leading companies to develop concepts for space exploration**
- Worked on separate teams**
- Recommendations presented at NASA Headquarters in Washington, D.C.**

Early Model



Concepts Explored

Key Points:

- Missions utilize multiple “single stick” rocket launches to deliver payloads & crew to orbit
- Rockets have different hardware modules onboard depending on mission
- Rockets not reusable; however, some payload modules might be recovered and used again
- Mission progressions must meet NASA timeline milestones

Exploration Model

ProModel Simulations:

- Created over a dozen different mission designs**
- Built in variability including launch delays, etc.**
- One run contains flight manifest sequence of all missions spanning about 20 years**
- Created several baseline models**
- Performed 100 replications for each study**
- Graphics library grew to over 85+ MB**

Exploration Model



Applications

Output Results:

- Process Cycle Times
- Mission Sequencing Impacts
- Inventory Requirements
- Reliability Impacts
- Metric Tons Flown
- Crew Days on Moon
- Consumables
- Others

tp 8.5 1-27--ldb - Output Viewer 3DR - [Report for tp 8.5 1-27-- (

File View Tools Window Help

Views: undefined view

Locations Location States Multi Location States Single/Tank Location Setup Resources

Location States Multi for tp 8.5 1-27-- (Avg. of 28 replications)

Name	Scheduled Time (MIN)	% Empty	% Part Occupied	% Full	% Down
TPSF Entry Q	507930.00	100.00	0.00	0.00	0.00
L110 1	507930.00	92.99	49.02	0.00	0.00
L110 2	507930.00	74.00	28.00	0.00	0.00
L110 2 Stage	507930.00	100.00	0.00	0.00	0.00
L110 3	507930.00	99.18	0.84	0.00	0.00
L110 4	507930.00	90.87	9.13	0.00	0.00
L110 5	507930.00	97.52	2.48	0.00	0.00
L110 6	507930.00	99.29	1.71	0.00	0.00
L110 7	507930.00	93.95	66.05	0.00	0.00
To NCProg Q	507930.00	100.00	0.00	0.00	0.00
L121 1 NCProg	507930.00	71.18	28.82	0.00	0.00

tp 8.5 1-27--ldb - Output Viewer 3DR - [Report for tp 8.5 1-27-- (Avg. of 28 replications)]

File View Tools Window Help

Views: undefined view

General Locations Location States Multi Location States Single/Tank Resources Resource States Node Entries

Locations for tp 8.5 1-27-- (Avg. of 28 replications)

Name	Scheduled Time (MIN)	Capacity	Total Entries	Avg Time Per Entry (MIN)	Avg Contents	Maximum Contents	Current Contents	% Utilization
TPSF Entry Q	507930.00	999999.00	48420	0.00	0.00	9.00	0.00	0.00
L110 1	507930.00	999999.00	2472.96	913.28	2.94	22.80	0.15	0.00
L110 2	507930.00	999999.00	14025.48	75.20	0.70	26.50	0.80	0.00
L110 2 Stage	507930.00	999999.00	747.50	0.80	0.80	3.60	0.80	0.00
L110 3	507930.00	999999.00	638.75	5.43	0.81	2.15	0.80	0.00
L110 4	507930.00	999999.00	4067.80	17.23	0.14	10.70	0.85	0.00
L110 5	507930.00	999999.00	2483.25	5.41	0.83	3.65	0.80	0.00
L110 6	507930.00	999999.00	1040.55	5.50	0.82	2.80	0.10	0.00
L110 7	507930.00	999999.00	3077.45	257.25	1.65	23.45	1.30	0.00
To NCProg Q	507930.00	999999.00	0.00	0.00	0.00	0.00	0.00	0.00
L121 1 NCProg	507930.00	999999.00	1613.95	132.18	0.42	8.30	1.85	0.00
L122 1 NCProg	507930.00	999999.00	0.00	0.00	0.00	0.00	0.00	0.00
L122 1	507930.00	999999.00	7184.30	131.56	1.34	17.95	1.30	0.00
To CHC Mktg Q	507930.00	999999.00	428.60	2.78	0.00	2.80	0.00	0.00
L122 2 CHC Mktg 1	507930.00	1.00	1017.60	57.51	0.12	1.00	0.15	11.64
L122 2 CHC Mktg 2	507930.00	1.00	294.75	88.94	0.06	1.00	0.85	5.14
L122 2 CHC Mktg 3	507930.00	1.00	80.25	108.25	0.02	1.00	0.80	1.74
L122 2 CHC Mktg 4	507930.00	1.00	1792.40	68.83	0.00	3.00	0.25	6.15
To Bandwidth Q	507930.00	999999.00	140.95	124.60	0.84	6.25	0.85	0.00
L122 3 Bandwidth	507930.00	1.00	392.65	33.76	0.09	1.00	0.10	4.34
L122 4	507930.00	999999.00	430.55	4.56	0.00	2.50	0.80	0.00
L122 5 PUs	507930.00	999999.00	618.65	2.80	0.00	2.10	0.80	0.00
L122 6 Comp-CHC	507930.00	999999.00	0.00	0.00	0.00	0.00	0.00	0.00
To Queuech Q	507930.00	999999.00	350.20	7.43	0.00	2.90	0.90	0.00
L122 6 Queuech 1	507930.00	1.00	688.95	78.84	0.10	1.00	0.15	16.31
L122 6 Queuech 2	507930.00	1.00	290.65	104.64	0.04	1.00	0.95	4.13
L122 6 Queuech 3	507930.00	1.00	876.60	84.84	0.07	2.00	0.25	7.27
L122 7 Bandwidth	507930.00	999999.00	1918.40	10.62	0.84	3.00	0.85	0.00
L122 8 Queuech	507930.00	999999.00	1.00	7.87	0.00	0.80	0.80	0.00
L122 8 Grinder	507930.00	1.00	67.75	14.88	0.00	1.00	0.80	0.20
L122 8 Raw-Machining	507930.00	999999.00	17.40	0.80	0.00	1.00	0.80	0.00
L123 1 Kahl-Kills 1	507930.00	1.00	1027.40	86.44	0.10	1.00	0.35	19.42
L123 1 Kahl-Kills 2	507930.00	1.00	334.40	94.10	0.06	1.00	0.20	6.19
L123 1 Kahl-Kills 3	507930.00	1.00	71.85	111.11	0.02	1.00	0.85	1.61
L123 1 Kahl-Kills 4	507930.00	1.00	20.80	159.38	0.01	1.00	0.80	0.68
L123 1 Kahl-Kills 5	507930.00	1.00	8.20	192.31	0.00	1.00	0.80	0.39
L123 1 Kahl-Kills 6	507930.00	1.00	1.60	47.81	0.00	1.00	0.80	0.24

Notional
Data

Reliability Impacts - Example

ProModel Simulation Model:

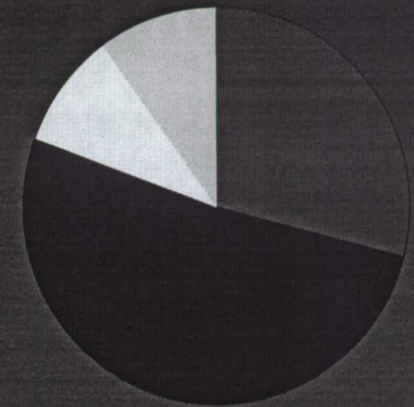
- Inputs an Excel spreadsheet with probabilities that negative events might occur at different stages of a mission, I.e., “probability that a rocket fails to deliver its payload to orbit”
- Model creates an Excel output file recording each event along with mission, rocket, date, location, payload modules on board, etc.
 - Derived Best, Worst, & Average Cases
 - Created a list of hardware needs

Reliability Impacts - Example

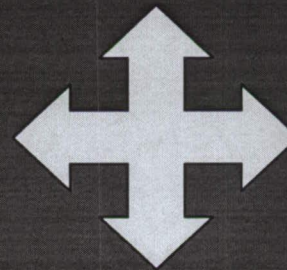
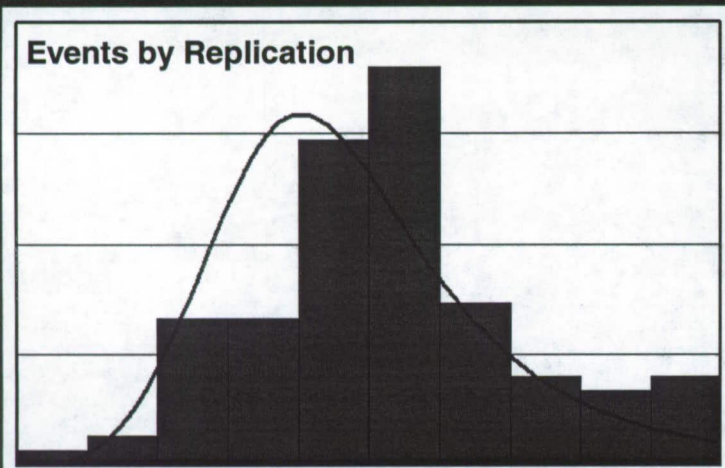
Notional Data:

Day #	Mission #	1st Entity Element	Launch	Location	RE Type
96.63,	1,	e_ELV_Heavy,	3,	I_Unload_Leo1,	1
1435.92,	4,	e_ELV_Medium,	5,	I_Launch_Pad,	2
1876.59,	5,	e_ELV_Heavy,	3,	I_Unload_Leo1,	1
2120.67,	7,	e_ELV_Medium,	5,	I_Launch_Pad,	3
4814.92,	15,	e_Earth_Departure_Stage,	3,	I_LEO,	5

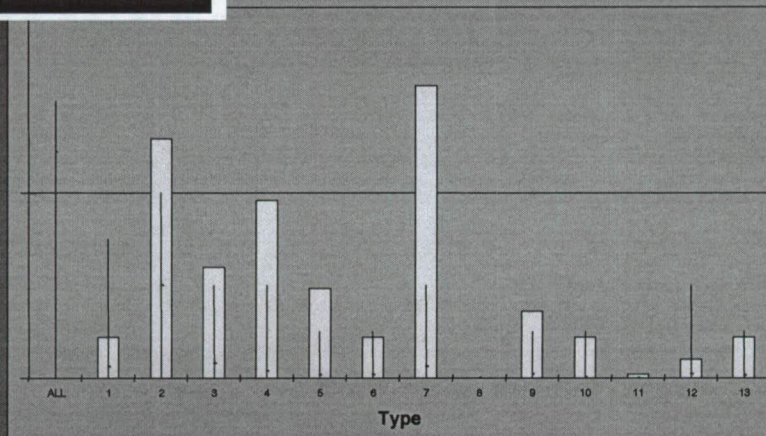
Events by Location



Events by Replication



Events by Type



Average Spares Required from Events:

2 ELV-H	1 ELV-M
2 EDS/PEDS	1 Cargo
1 LSAM	2 CM
1 MM	2 SM
1 Hab	

Concept Defined by NASA

Shuttle Derived Launch Vehicles (SDLV):

Constellation
Program

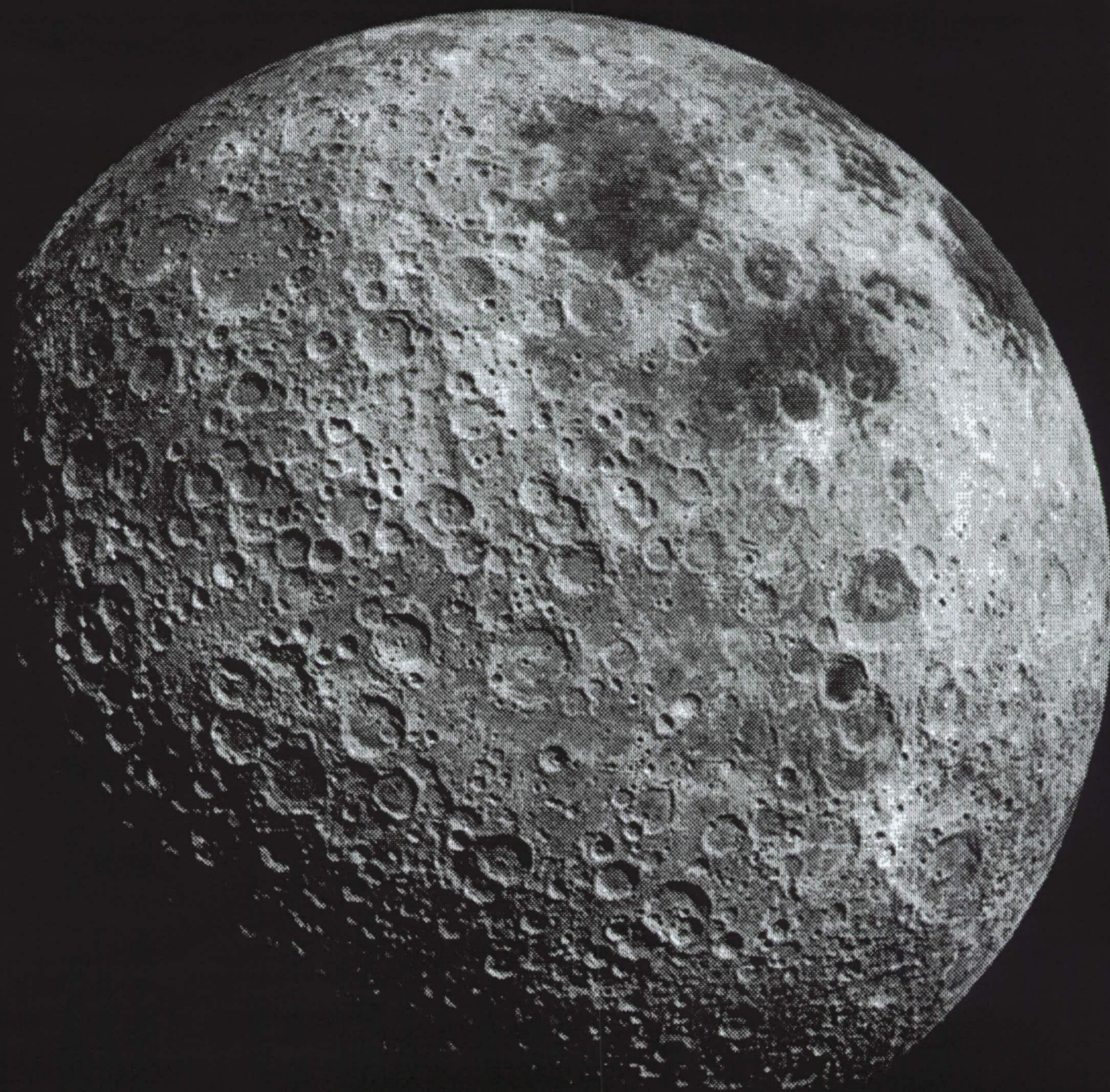


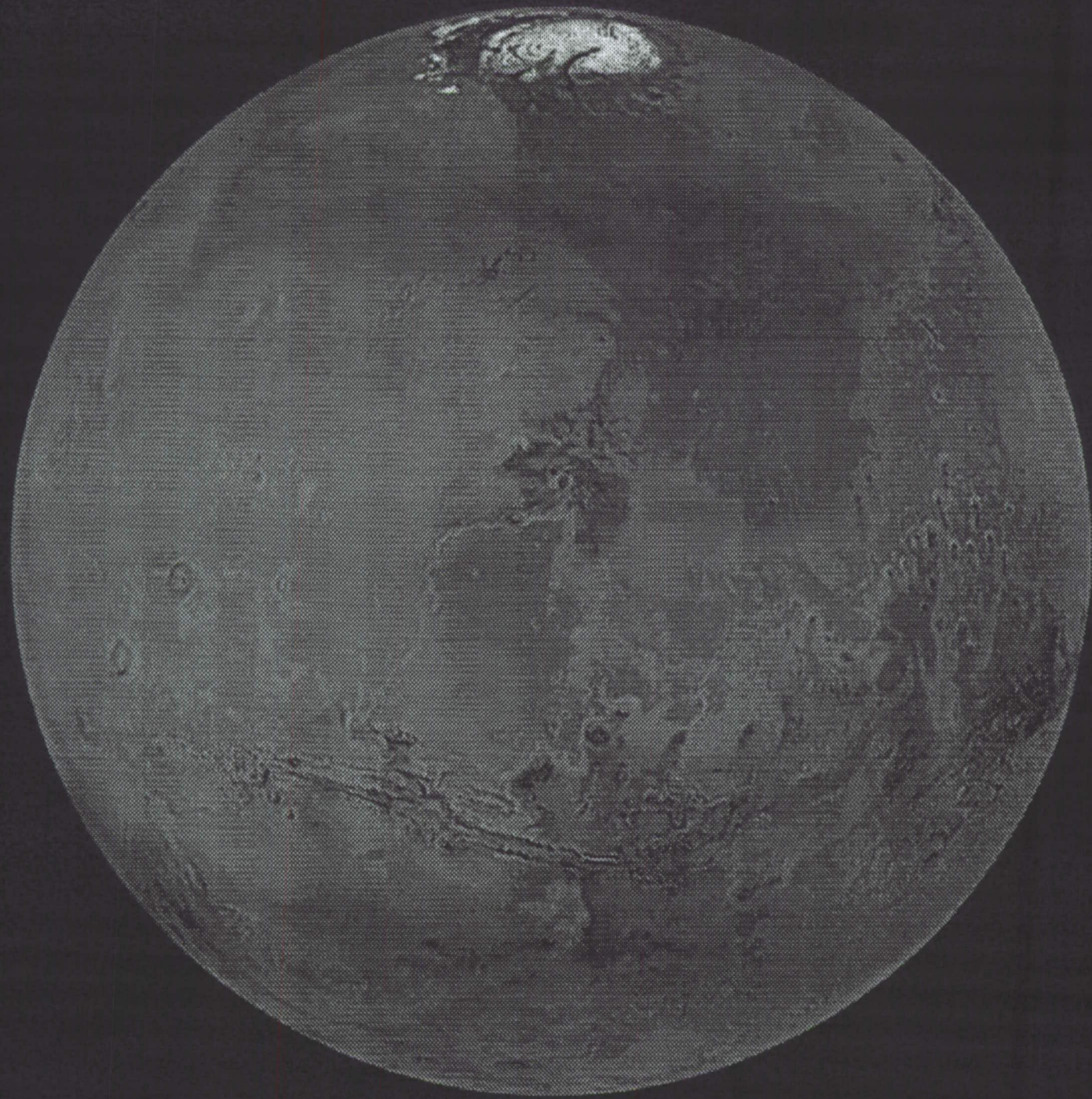
Next Steps

ProModel Simulation Projects:

- Developing SDLV models
- Opened more opportunities for simulations
 - Expanded M&S interest within USA
 - NASA emphasis on M&S in contracts
- Process simulation continues to be a vital tool in USA's Lean Six Sigma process improvement efforts



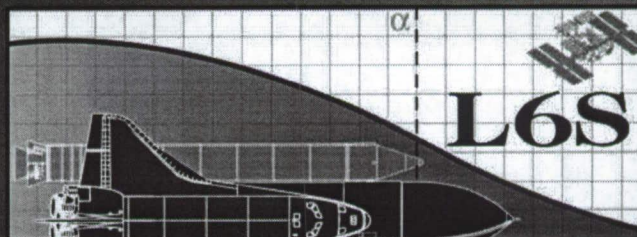






United Space Alliance

Thank You





Best of Hubble Photos

Viewable at <http://hubblesite.org/>
Or <http://nix.nasa.gov/>











